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Scintillation Scanning of Brain Tumors

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• **Brain scanning by means of externally placed moving scintillation detectors has proven to be an easy accurate method for demonstrating size, shape and position of many types of brain tumors. In a series of 53, there were few false negatives and few false positives. The procedure is easy on the patient, does not require anesthesia and can be done on outpatients. It is recommended as a screening procedure for all brain tumor suspects.**

IT HAS BEEN recognized for over 20 years[2] that the difference in degree of concentration of some radioactive isotopes in brain tumors when compared with the normal brain tissue is sufficient to permit delineation of tumor tissue by isotopic counting procedures.

Early efforts were directed toward the operative mapping of the extent of a tumor by probing the brain with a small geiger tube for beta-emitting radioactive phosphorus.[4] Later, radioactive I^{131}-tagged fluorescein[3] was used to detect concentrations of radioactivity with detectors positioned externally on the skull. By making counts over many comparable areas of each side of the skull and comparing the counting rates of matched points, differential concentrations of radioactivity could be detected. These methods required rather large doses of radioactive isotopes and scattered radiation made accurate detection difficult. Then Brownell,[1] at Boston, utilized positron-emitting isotopes obtained from a nearby cyclotron and detected them with moving external coincidence counters. The expense of the scanning unit and the limited availability of short-lived cyclotron isotopes restricted this approach to a few institutions.

Beginning in the early 1950's, commercial scanners became available that utilized larger, more sensitive scintillation crystals for detecting radiation and coupled these with heavier, thicker collimators and with pulse height spectrometry which permitted discarding the scattered radiation and made the detection much easier. These technical improvements permitted mechanical scanning of the skull with sufficient accuracy to demonstrate large tumors. Photoscanning devices were added later, permitting further accentuation of small differences in concentration of radioactivity. This is the current status and the method makes a reasonably fine detection of difference in concentration between a small target and a non-target area. Future scanning will undoubtedly be stationary with instantaneous visualization of the entire area of isotopic concentration.

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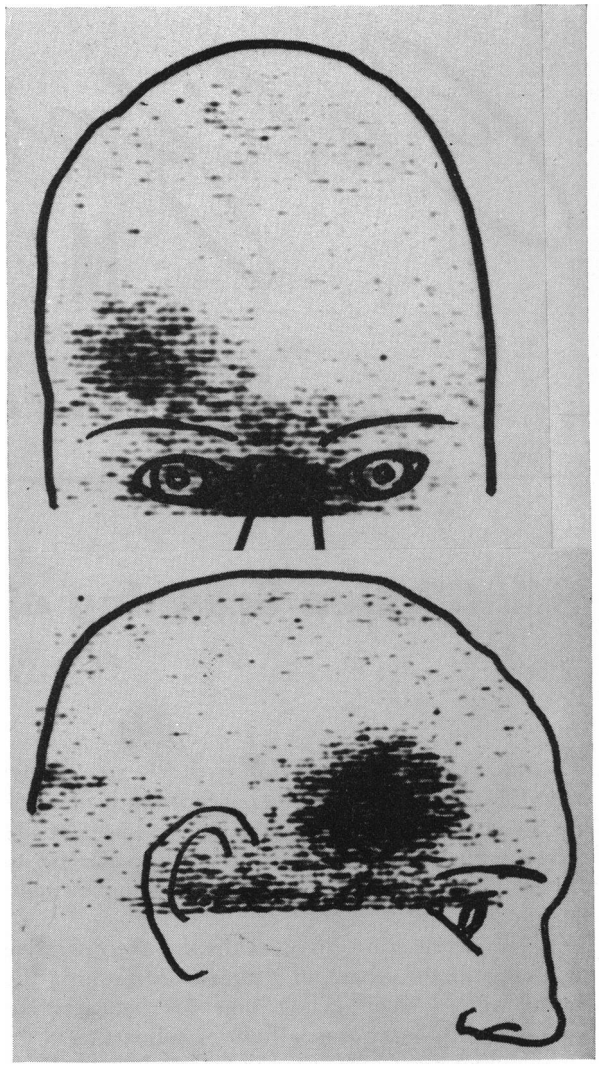
MATERIALS

The two radioactive isotopes currently used for scintillation scanning of brain tumors are radioactive mercury (either 203 or 197) and radioactive iodinated human serum albumin. Mercury has the advantages of a longer half life, permitting greater

availability, besides good concentration in the tumor tissue and rapidity of concentration. After six hours, the activity of mercury in the blood vessels of the brain has almost disappeared, leaving only tumor tissue concentration. This permits one-day scanning procedures. They are carried out one to two hours after injection if there is need for a reading of the activity of the mercury in the blood vessels; if not, the scan is made six hours after injection. The disadvantages of mercury are that it sometimes deteriorates on the shelf and fails to concentrate accurately in the tumor, that it is trapped by the kidneys and retained for long periods, and that its rapid disappearance from the bloodstream occasionally results in the inability to visualize normal structures, thus making comparison of tumor tissue concentration difficult. Iodinated human serum albumin has a shorter half life, does have some allergenic propensity, has to be refrigerated and requires a two-day procedure; but it is more consistent in providing a normal vascular pattern against which abnormalities become more easily detectable. Physiologic concentration occurs with both isotopes unless prevented by the previous administration of blocking agents. The kidney concentration of radioactive mercury can be reduced by previous administration of non-radioactive meralluride (Mercuhydrin®) or chlormerodrin (Neohydrin®). The thyroidal uptake of radioactive I^{131} can be minimized by the previous administration of small amounts of Lugol's solution.

The procedure can be done on outpatients, does not require anesthesia, and is not particularly uncomfortable to the patient other than the discomfort of holding still while the scan is being done. The probe does not touch the patient, and there is no pain, pressure or other discomfort during the procedure.



Right sphenoid ridge meningioma shown by scan superimposed on skull outline.

TECHNIQUES

Procedure: An intravenous injection of molar lactate is started to be sure that the test material will be introduced into the bloodstream. When the intravenous flow is satisfactory, the test dose material is injected into the tubing. We use between five and eight microcuries for each kilogram of body weight of radioactive mercury-203 or radioactive serum albumin-131. If mercury is used, the patient is scanned two hours and six hours after injection. If iodinated albumin is used, scanning is done between 20 and 26 hours after the injection. The first scan is done with the suspected side of involvement facing up. Care is taken to be sure that the canthal line is perpendicular to the floor and that the sagittal plane is horizontal. Otherwise, the vascular concentrations at the base of the brain will be superimposed and interfere with the detection of low lying lesions. The patient's head is supported with sand bags so as to be held reasonably rigid in position and the patient is told not to move. The scan is started at the top of the skull with the surface of the focusing collimator as close to the scalp as possible without touching the skin. The scan is continued until it has passed the orbital meatal line by approximately one inch.

Technical factors are as follows: (1) Dot factor: 1 in 2 or 1 in 4; (2) Speed: 24; (3) Spacing: 2.5 mm; (4) Pulse height spectrometry with a window set from 300 to 450 KEV; (5) A 3 K scale; (6) A background erase of 24 per cent; (7) A 19-hole, 2½-inch focusing collimator; (8) Density: 25; (9) Range differential: 15; (10) A 2 mm square light collimator. To minimize the scanning time, the axis of the scan is kept perpendicular to the orbito-meatal line. At the conclusion of the scan, point by point localizations of the canthi, nasion,

orbital ridge, tip of the nose, external auditory meatus, and surface contours of the skull are done and drawn on the printed scan. If there is an obvious tumor localization on the printed scan, the probe is positioned over the peripheral portions of the tumor and indelible pencil marks are made on the skin of the patient to outline the limits of the tumor. After the photoscan is developed, the photoscan is superimposed on the print scan and the reference points are transferred to the photoscan. The photoscan is then compared with x-ray films of the skull for additional help in localization of the tumor. The photoscan is then placed on a view box and copied with a Polaroid camera. By adjusting the lens opening and exposure time, varying degrees of contrast enhancement can be obtained. The patient is then turned into either a face up or face down position, depending on whether the tumor shown on the lateral scan was more anterior or posterior. Care is again taken to be sure that the orbito-meatal line is vertical. Similar procedures are followed until both lateral and face up or face down Polaroid prints are available. These are then mounted on the patient's chart for the convenience of the referring physician. For lesions that are difficult to visualize, ink arrows are used to point out the area of suspected tumor.

RESULTS

Of 53 brain scans, 26 were positive for concentrations of radioactivity and 27 were negative. There were two false positives, one of which was due to an infratentorial cyst and the other due to a fresh hemorrhage. In each case, the isotopic concentration coincided with the pathologic condition present, but neither was due to tumor. There were two known cases of tumor in which the scans were negative. One of these was due to a low grade fibrillary astrocytoma and the other due to hypothalamic tumor (not biopsied) subsequent to radiation therapy. Among the cases in which findings were positive, there were five gliomas, four meningiomas, four astrocytomas, three pituitary tumors, and eight cases of metastatic carcinoma. The primary sites of carcinoma in which there was demonstration of cerebral metastasis included lung, thyroid, breast and testicle. When the lesions were clearly visible, the size, shape and position were more readily appreciated than on any other diagnostic procedure. If some allowance was made for minor magnification of the size of the tumor on the scan dependent upon its position within the substance of the brain, the size of the tumor as shown by the scan corresponded very closely to the actual size of the tumor as removed surgically.

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